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OCS Report
MMS 91-0011

North Carolina Physical Oceanography Panel Report

U.S.Department of the Interior
MMS Minerals Management Service
Atlantic OCS Region

COMPLETED

North Carolina Physical Oceanography Panel Report

U.S.Department of the Interior
Minerals Management Service
Atlantic OCS Region

April 1991

This manuscript has been reviewed by the MMS, and approved for publication. The opinions, findings, conclusions, or recommendations expressed in this report are those of the authors, and do not necessarily reflect the views or policies of the MMS. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ACKNOWLEDGEMENT

Mr. Joseph V. Mullin, Environmental Studies Unit, Atlantic OCS Region, was the Physical Oceanography peer review panel coordinator.

TABLE OF CONTENTS

Section — Page

I. Executive Summary 1

II. Physical Oceanography Panel Report 5

III. Figure 1. (proposed locations of current meter moorings) 11

IV. Appendix 15

1. January 29, 1990, letter from the Regional Director, MMS Atlantic OCS Region to the National Research Council (NRC), the names of three nominees to be panel members. 17

2. March 9, 1990, letter from the NRC to the Regional Director, MMS Atlantic OCS Region, providing the names of three nominees to the panel. 21

3. March 12, 1990, letter from the Regional Director to Ms. Donna Moffitt, North Carolina Outer Continental Shelf Office, providing the list of three physical oceanographers nominated by the NRC. 22

4. March 19, 1990, letter from Ms. Donna Moffitt, North Carolina Outer Continental Shelf Office, to the Regional Director, MMS Atlantic OCS Region, indicating North Carolina's choice of the final panel member. 24

5. June 21, 1990, letter and statement of work from the Regional Supervisor, Leasing and Environment, MMS Atlantic OCS Region, inviting the physical oceanography panel to attend the panel meeting. 25

TABLE OF CONTENTS

Section Page

IV. Appendix (continued)

6. July 19, 1990 letter from the Regional Supervisor, Leasing and Environment, MMS Atlantic OCS Region, to the physical oceanography panel members finalizing the dates of the panel meeting. 32

7. September 20, 1990 letter from Mr. Joseph V. Mullin, MMS panel coordinator to panel members, containing the proposed agenda and an explanation of the panel tasks. 33

8. North Carolina Peer Review Panel Members 38

9. List of attendees at the physical oceanography panel meetings. 39

10. October 29, 1990 letter from Mr. Joseph V. Mullin, MMS panel coordinator to panel members, requesting a review of the final draft panel report. 40

11. January 14, 1991 letter from Mr. Joseph V. Mullin, MMS panel coordinator to panel members, requesting a review of the final of the panel report and a signed statement of acceptability. 41

12. Comment letters from the panel members, and signed statements indicating that this report accurately reflects the findings and recommendations of the panel. 42

EXECUTIVE SUMMARY

North Carolina Physical Oceanography Panel

The Interior Department's FY 1990 Appropriation Committee Report directed the Minerals Management Service "to conduct a study of the ocean current circulation patterns between Cape Hatteras North Carolina and the Chesapeake Bay, and that the study design and results, be evaluated by a scientific peer review panel consisting of three physical oceanographers; one each to be designated by the Secretary of the Interior, the Governor of North Carolina, and one chosen jointly by the Secretary and the Governor of North Carolina from nominations submitted by the National Academy of Sciences."

The MMS intended to have the panel review the study design for the literature synthesis study titled, "Quasi Steady State Perturbation and Intrusions of Virginia Coastal Waters Offshore North Carolina", before the study was procured and study products after procurement. In January 1990, the MMS prepared a draft Statement of Work (SOW) for the study.

In February 1990, Mobil Oil Corporation submitted a draft report to the MMS titled, "Characterization of Currents at Manteo Block 467 off Cape Hatteras, North Carolina." This report was prepared by Science Applications International Corporation (SAIC) for Mobil Exploration and Producing Services Inc. The report was prepared to document the present state of knowledge of the physical oceanography of the Gulf Stream circulation regimes which occur offshore Cape Hatteras, North Carolina at Manteo Block 467 and the nearby region.

The MMS and the State of North Carolina agreed that the report appeared to satisfy the requirements of the planned literature synthesis study. The MMS agreed to form the scientific review panel and have the panel review the SAIC prepared report to determine if it could be used in lieu of the MMS planned literature synthesis study.

In a March 19, 1990, letter from the State of North Carolina to MMS, Donna Moffitt, Director of the North Carolina Outer Continental Shelf Office, stated, "I am particularly pleased that your staff has found Mobil's recent document, 'Characterization of Currents at Manteo Block 467 Off Cape Hatteras, North Carolina' an important work. It synthesizes much of the available current data North of Cape Hatteras and concludes on pp 22. (Mobil report) that 'the sparseness of physical oceanographic data from the shelf between Cape Hatteras and the [Chesapeake] Bay precludes drawing a conclusion. Since there has never been a comprehensive observational program on this portion of the shelf, a coherent description of the shelf physical oceanography for the area may not be given.' To the extent this document can be used to save time and money in the Congressionally-mandated synthesis study, I would support that approach."

The procurement of the MMS planned study was postponed by the Atlantic OCS Region until the panel was formed and had the opportunity to review the Mobil report. The scientific peer review panel was convened in Herndon, Virginia, September 24-26, 1990 and included:

- Dr. Larry Atkinson, Old Dominion University (Selected by the Minerals Management Service)
- Dr. John Bane, University of North Carolina (Selected by the State of North Carolina)
- Dr. Kenneth Brink, Woods Hole Oceanographic Institution (Jointly selected by the Minerals Management Service and the State of North Carolina)

The panel was charged with the following tasks:

1. Evaluate the Mobil report titled "Characterization of Currents at Manteo Block 467 off Cape Hatteras, North Carolina," to determine if it is an adequate summary of published and unpublished literature on physical oceanography off North Carolina.
2. Provide recommendations on the need for additional physical oceanographic field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina, in order to make environmental assessments of the potential impacts of OCS development.
3. If additional field measurements are deemed necessary recommend data collection requirements, sampling criteria, methodology, and station locations necessary to acquire the data.

In their report, the panel stated that "the Mobil report was mainly for the engineering design of the exploratory drilling operation at the single Mobil site in Manteo Block 467. Although the report was considered more than adequate for the purpose intended." The panel also concluded that "the report was an adequate description of the circulation processes at the Mobil site (Block 467), but did not treat areas more than a few kilometers away, specifically the continental shelf." Adequacy, as judged by the panel, was based upon the standard of site specific data versus regional data. The panel concluded that "the Mobil report did not satisfy all of the requirements of the planned MMS synthesis of existing literature, data, and satellite imagery", because the data was too site specific.

The panel made the following recommendations:

1. A literature and data review consisting of two parts should be conducted. The first part should be a process-oriented synthesis of physical oceanographic information of the region and be the same quality as a peer-reviewed paper. The second part should be a catalog of existing data sets.

2. Additional field measurements are required because there is inadequate information on circulation and exchange processes in the region. The panel recommended a field program consisting of moored instrument arrays for at least two years; hydrographic surveys; collection of sea level, and meteorological data; satellite sea surface temperature imaging; and surface drifters.

3. The panel recommended the name of the literature synthesis study be changed from "Quasi Steady State Perturbation and Intrusions of Virginia Coastal Waters Offshore North Carolina", to "A Review of the Physical Oceanography of the Cape Hatteras, North Carolina Region."

The MMS has funded and intends to procure both studies recommended by the panel.

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REPORT OF THE NORTH CAROLINA PHYSICAL OCEANOGRAPHY PANEL TO REVIEW THE SYNTHESIS OF AVAILABLE PHYSICAL OCEANOGRAPHIC INFORMATION OFFSHORE NORTH CAROLINA

Prepared and edited by Drs. Larry Atkinson, John Bane, and Kenneth Brink.

Tasks and Questions are quoted for clarity.

Task 1.

"Evaluate the report entitled "Characterization of Currents at Manteo Block 467 off Cape Hatteras, North Carolina," and determine if it is an adequate summary of published and unpublished literature on physical oceanography off North Carolina."

A. Evaluation of the report.

The report was produced by Science Applications International Corporation (SAIC) for Mobil Exploration and Producing Services Inc. The purpose of the report was mainly for engineering design of the exploratory drilling operation at the single Mobil site in Manteo Block 467. The report is more than adequate for the purpose it was intended. It did not attempt to provide the information necessary for environmental impact assessment. For example there is little discussion of currents over the continental shelf.

B. Is it an adequate summary of the published and unpublished literature?

The report was an adequate description of the processes at the Mobil site but did not treat areas more than a few kilometers away, specifically the nearby continental shelf.

C. Does the report satisfy the requirements of a planned MMS review and synthesis of existing literature, data, and satellite imagery to:

1. Characterize the variability of the circulation of coastal and continental shelf waters offshore North Carolina in terms of the circulation field, duration and frequency of occurrence, seasonal variation, and the thermal and salinity structure.

This topic is not treated by the SAIC report.

2. Describe the causative factors responsible for the observed variability, including a thorough review of the hydrography of the study area.

> These topics are discussed only in the context of the Mobil drilling site. No information is given for the Slope Sea and continental shelf, which were beyond the scope of the report.

3. Describe factors that influence the character and variability of these perturbations including the Gulf Stream, meteorological conditions, and intrusions of Virginia coastal waters.

> Gulf Stream meanders are discussed but their role in influencing shelf current variability is not treated. Gulf Stream rings (warm and cold), atmospheric forcing, and currents over the continental shelf are not discussed.

4. Describe the intrusions of Virginia coastal waters onto the continental shelf and slope, offshore North Carolina, in terms of the frequency of occurrence. If possible through a review of existing data, characterize the duration, volume of water involved, seasonal occurrence, thermal and salinity structure of the intruding water, and the current fields associated with the intrusions.

> The SAIC report does not treat this subject.

D. Recommendation for a Literature Review

We find that a literature and data review is needed to summarize and critique the state of knowledge of physical oceanographic conditions in the Cape Hatteras region. We envision a two-part final document. The first part is to be a process-oriented synthesis of knowledge of this region. The report should be of the same quality as a peer-reviewed published review paper. The second part of the document is to be a catalog of existing data sets, including information on the type of data taken and where (including depth ranges) and when the measurements were made. The region should include the area bounded by 34.5N to 37N latitude and from the shoreline eastward to 73W longitude (but excluding Chesapeake Bay). Mean conditions and variability on time scales ranging from hours to interannual should be included. We suggest the following items be addressed in the review of literature and data.

1. Processes - This should be a synthesis of our understanding of physical oceanographic processes relevant to oil and gas activities off North Carolina and Virginia. Topics to be considered should include, but not be limited to the following:

> Atmospheric forcing of hydrographic variability, mixing, currents, and surface waves;
>
> Gulf Stream variability including path variations, meanders, frontal eddies, filaments, and intrusions;
>
> Effects of warm and cold core rings, especially in regard to how they affect the Gulf Stream's path and shelf/slope exchange processes;
>
> Regional bottom boundary layer processes;
>
> Shelf break processes, emphasizing exchange across the shelf break front;
>
> Shelf current variability with attention to wind and buoyancy driven flow including southward Virginia Coastal water intrusions;
>
> Shelf/estuary exchanges focussing on processes moving shelf water into the estuary;
>
> Slope Sea current variability including eddies in the Slope Sea and interactions with adjacent shelf waters;
>
> Tides, especially as they pertain to mixing and particle transport.

2. Summary of Existing Studies - A summary of studies, data sets and publications. This section is a description of studies including objectives, motivations, data obtained, and geographical and temporal distribution of measurements. This section is not a synthesis. The summary should cover the following:

> Hydrographic conditions of the continental shelf, slope, and Gulf Stream. Variables should include temperature, salinity, density, and nutrients.
>
> Lagrangian measurements. Of particular interest is surface and near-surface circulation.
>
> Meteorological forcing. The primary variables of interest are surface wind stress and sensible and latent heat fluxes. Attention should focus on studies synthesizing the extensive existing meteorological data base.

Moored instrument measurements. Variables should include horizontal velocity, temperature/salinity, and bottom pressure. Bottom boundary layer observations should also be included.

Remote sensing data including sea surface temperature and ocean color.

Sea level and other coastal measurements. Coastal sea level and other shore-based measurements such as temperature and salinity.

Wave climatology. Surface wave climatology, especially directional wave spectra.

Task 2

"Provide recommendations on the need for additional physical oceanographic field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina, in order to make environmental assessments of the potential impacts of OCS development."

The panel recommends additional field measurements be made because it believes there is inadequate information on circulation and exchange processes in the region to fully characterize its physical oceanography. The panel realizes that while the recommended literature review may reveal important new data sets and information an appropriate field program can be designed now.

Specific areas where information is lacking include circulation over the continental shelf, how offshore waters are transported onto the continental shelf and transport within the inner shelf region to the beach. More information is required regardless of the risk assessment approach taken by MMS.

If a model-oriented method (current OSRA approach) is taken, more needs to be known about the flow field (especially over the shelf and in the Slope Sea) in order to drive and validate numerical models and to establish which processes are important.

If a more empirical approach to risk assessment is made, a thorough study of near surface Lagrangian velocity at the Mobil site, and any other potential lease sites, must be made since the panel believes such a data base is almost entirely lacking. Field programs for both approaches are recommended below.

Task 3.

"If additional field measurements are deemed necessary recommend data collection requirements, sampling criteria, methodology, and station locations necessary to acquire the data."

A. OBJECTIVES OF THE FIELD PROGRAMS

The main objective of the recommended field program is to develop an adequate understanding of the physical oceanography of the Cape Hatteras region. This region is perhaps one of the most complex oceanographic regions around the United States. This complexity is due to interactions among the northward flowing Gulf Stream (with its meanders, eddies and filaments), the southward flowing coastal current north of Cape Hatteras, the currents in the bays south of Cape Hatteras, the southward flowing deep western boundary current along the upper continental slope, and the nearby Slope Sea circulation where cyclonic and anticyclonic eddies reside. The complexity of the region must not be underestimated and any field study should be well planned and reviewed.

The principal field program described consists of a comprehensive physical oceanographic study. An additional, optional, smaller scale Lagrangian drifter program specific to the Mobil site is also described.

B. THE PROCESSES TO BE STUDIED

The field program outlined in the next section addresses the processes associated with flow between the slope area and the shelf break, flow across the shelf break, alongshore flow on the shelf, and cross-isobath flow towards the beach in the inner shelf zone. The proposed plan is based on the panel's knowledge of the time and space scales at which these processes probably operate.

The major issue ultimately to be addressed is the extent to which contaminants released over the continental slope can penetrate onto the shelf and thence shoreward. In order to address this, we divide the conceptual design into questions of flow patterns in specific regions.

1. Over the slope and farther offshore, flow is primarily influenced by the Gulf Stream and its variability, the Slope Sea circulation and large, coherent eddies (e.g., warm core rings). We do not at present understand the extent to which slope flows, especially away from the Gulf Stream, can advect water parcels towards the shelf. Attention should be given to Gulf Stream

meanders, frontal eddies, warm and cold core rings and the effect of the deep western boundary current on the Gulf Stream path.

2. At the shelf break, there is often either a shelf break front or a Gulf Stream front. In either case the front's existence implies an obstacle to shelf-slope exchange. Such exchange is known to take place, but its frequency, kinematics, and dynamics are poorly understood. It is thus necessary to dedicate a substantial effort toward understanding how the outer shelf fronts can be penetrated by offshore water. Particular attention should be given to the shelfbreak front, since the Gulf Stream front has, to some extent, been considered by the past studies upstream of Cape Hatteras, such as the Frontal Eddy Dynamics Study. Consideration should be given to frontal stability, wind-driven transport and eddy forcing of shelf currents, among other possibilities.

3. Our present knowledge suggests that mean flow over the mid to outer shelf is equatorward north of Cape Hatteras and poleward south of the Cape. This suggests that there must be a convergence and net offshore flow at or near the Cape. At present, we have no useful measurements or even conceptual models as to how this flow takes place, although we do know that some of the shelf water has been observed along the northern edge of the Gulf Stream (the often-referred-to Ford water). Since cross-shelf exchange is a crucial issue, it is important to know the frequency and rate of flow convergence, and what processes contribute to its variability.

4. At present, there are no measurements (known to this panel) available to estimate the tendency for shelf water parcels to move shoreward. The panel recommends that studies of cross-shelf exchange be carried out with an emphasis on the ability of water parcels to cross the nearshore zone to the beach.

C. THE PRINCIPAL FIELD PROGRAM

Measurements should be made with an array of instruments moored within the region for two years. Several surveys of the hydrographic structure of the region should be conducted in the region with concentrated surveys of strong events. The strong events are known to occur within the region and may affect exchanges and transports in important ways. Additionally, routinely available data on coastal sea level and meteorological variables plus satellite sea surface temperature imagery should be collected for analysis along with other data collected in the field programs.

1. The Moored Arrays

The locations of the recommended moored arrays is shown in Figure 1.

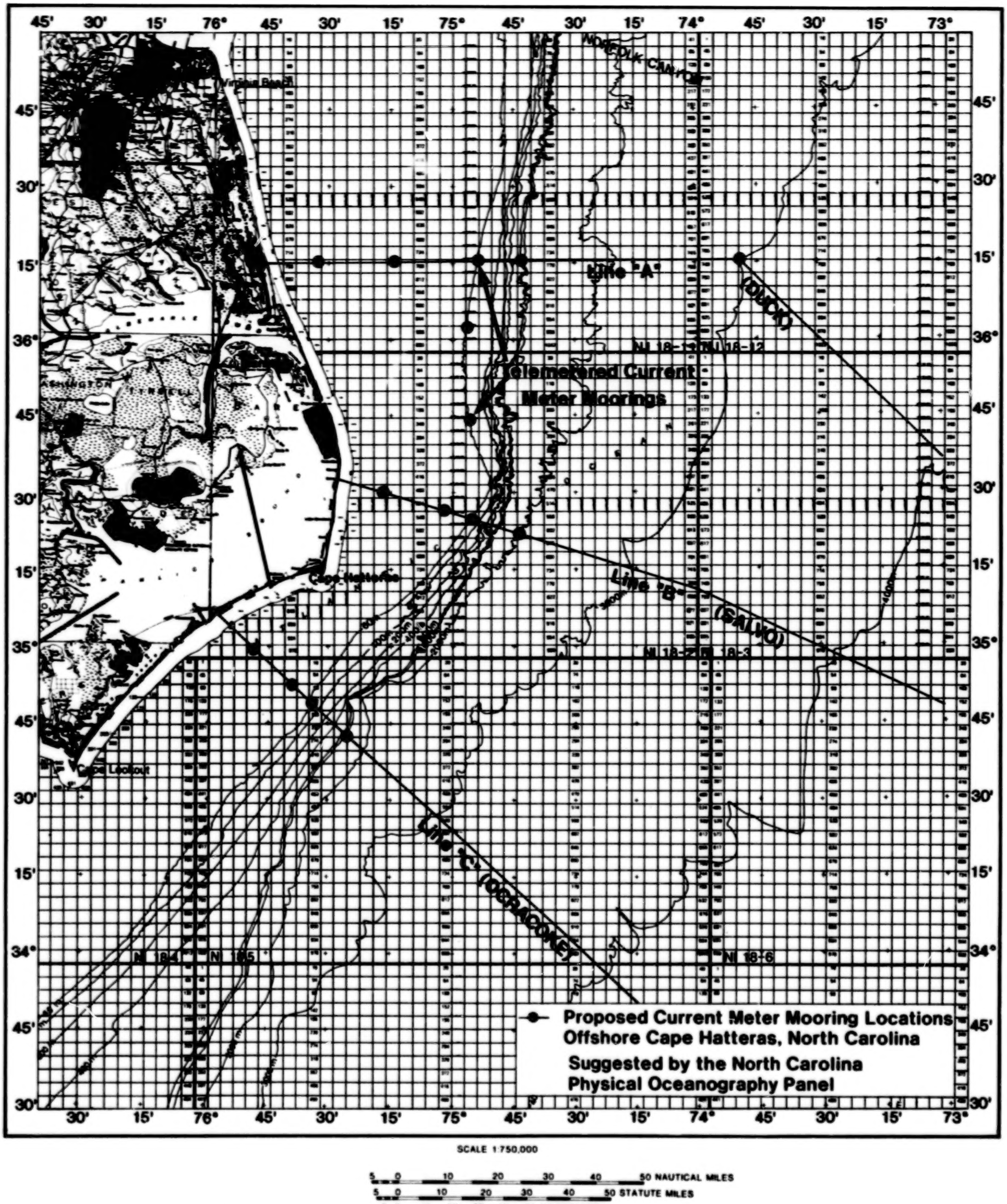
45'
30'
15'
76°
75°
74°
73°
36°
35°
34°
Virginia Beach
NORFOLK CANYON
Line "A"
(DUCK)
NI 18-11
NI 18-12
Telemetered Current
Meter Moorings
Cape Hatteras
Line "B"
(SALVO)
NI 18-2
NI 18-3
Cape Lookout
Line "C" (OCRACOKE)
NI 18-4
NI 18-5
NI 18-6
Proposed Current Meter Mooring Locations
Offshore Cape Hatteras, North Carolina
Suggested by the North Carolina
Physical Oceanography Panel
SCALE 1:750,000
5 0 10 20 30 40 50 NAUTICAL MILES
5 0 10 20 30 40 50 STATUTE MILES
5 0 10 20 30 40 50 KILOMETERS

Figure 1

BEST COPY AVAILABLE

The panel believes this plan will provide data sufficient to significantly increase our knowledge of circulation processes in the area. Thirteen moorings are positioned on three cross-shelf lines (A, B, and C, extending seaward from Duck, Salvo, and Ocracoke, North Carolina, respectively). On each of the three cross-shelf lines, moorings should be placed in water depths of 20m, 35m, 60m, and 2000m with a thirteenth mooring on the 3,000m isobath on the Duck line. Two additional shelf edge moorings should be placed on the 60m isobath, equally spaced between the 60m moorings on the Duck and Salvo lines.

Instrument depths are recommended as follows:

20m isobath moorings: 5m and 15m
35m isobath moorings: 5, 20, and 30m
60m isobath moorings: 5, 30, and 50m
2000m isobath moorings: 200, 500, 1000, and 1900m
3000m isobath mooring : 200, 500, 1000, and 2000m

The shallow water instrument moorings will likely require servicing at 3 month intervals.

2. Telemetry

Two of the moorings on the 60m isobath should be instrumented in a manner to telemeter data from at least one of the current meters to a shore-based station. The telemetered data may be used in conjunction with satellite sea surface temperature imagery to determine if an unusual event may be about to occur. The two moorings to be instrumented for telemetry are the northernmost and third northernmost ones on the 60m isobath (See Figure 1.)

3. Event Surveys

The nature of events that exchange waters between the Slope Sea and shelf and that transport water across the nearshore zone need to be better determined. Because of the episodic character and small spatial scales that these events likely have, special surveys must be conducted to delineate properties and assess their importance. The panel suggests that several event studies be conducted, either from a boat/ship or aircraft, or both. These event studies will require that the vessel be available for quick response to an imminent exchange event as indicated by satellite imagery and/or data telemetered from the shelf break moorings. Instrumentation to be used may included XBT's, a CTD and ADCP, drifters from a ship or boat, AXBT's, AXCTD's and AXCP's, and drifters from an aircraft.

4. The Nearshore Front

The movement of floating or suspended material from the outer shelf to the inner shelf and ultimately to the beach or marshes is often controlled by the position and strength of the coastal or near-shore front. The existence, strength, and position of the front is often determined by the local buoyancy flux (freshwater runoff) and the mixing forces (wind, tidal currents). In the Cape Hatteras region it is likely that low salinity water from the Chesapeake Bay flows southward along the coast forming a stratified zone over the inner shelf. With distance from the Bay the front may weaken and the position offshore change.

Our present knowledge of the seasonal characteristics of the nearshore front is very limited. We recommend surveys of the region on a seasonal basis to determine the alongshore and across shelf position and structure of the front. The survey could be done by a small, CTD-equipped ship or an aircraft using AXCTDs. The survey should be done seasonally over a two year period.

A successful field program must include the following additional components:

- Measurements of winds, coastal sea level and atmospheric pressure should be obtained from all existing stations near or on the coast and within 500 km of Cape Hatteras. These data sets will be useful for estimating forcing and testing dynamical hypotheses.
- Near-surface Lagrangian experiments will need to be conducted as a method for general flow visualization. In addition, carefully designed drifter experiments will be needed to study exchange across the nearshore zone and across the shelf break.
- Satellite infrared data will be required to interpret other measurements in their proper spatial settings. In addition, these observations will be critical for real-time monitoring and planning the event surveys.

D. A SEPARATE LAGRANGIAN DRIFTER PROGRAM

It is possible to begin accumulating useful data in the very near term. This could be done by starting a time series of weekly drifter deployments at the proposed site of the Mobil exploratory well. Such a time series should continue for at least two years. The most desirable type of drifter would be one that is demonstrated to follow water very well such as the WOCE drifter. It may be worthwhile to deploy drifters in a repeated pattern, rather than single deployments at a point. It would also be useful, in addition, to deploy drifters which behave, to a high degree of confidence, like oil and gas related contaminants. Further, if deployment is from a boat, it would be desirable to accumulate underway acoustic Doppler current estimates.

There are serious disadvantages to this approach, however. First, even with perfect drifters, the results would only be applicable for the specific repeated launch sites, any site more than 1 km away would require a whole new study. Further, water-following drifters do not behave as oil and gas related contaminants do, and the oil-imitating drifter has still not been perfected. Finally, such an entirely kinematical approach does not give a process-oriented data set which could be used directly to obtain a physical understanding.

The study would require Argos monitoring of the float trajectory and acquisition of satellite sea surface temperature data. The data should be given an appropriate statistical analysis relevant to specified risk analysis procedures. The satellite data should be accumulated to allow interpretation of the float trajectories.

A comment from the physical oceanography panel on Regional Studies List, Number 5., proposed project entitled "Quasi Steady-State Perturbations and Intrusions of Virginia Coastal Waters Offshore North Carolina."

1. The panel recommends that the title be changed to "A review of the physical oceanography of the Cape Hatteras region." The present title makes no sense oceanographically.

2. The study referred to in this proposed project is defined in the section of this report entitled "Recommendation for the Literature Review" (TASK 1.D.).

APPENDIX

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United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Atlantic OCS Region
381 Elden Street, Suite 1109
Herndon, Virginia 22070-4817

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JAN 29 1990

Dr. Phillip Smith
Executive Officer
National Research Council
2101 Constitution Avenue, NW.
Washington, D.C. 20418

Dear Dr. Smith:

The Congress, through our 1990 Appropriations Bill charged the Department of the Interior with convening a panel of three physical oceanographers. The purpose of this panel is to review the design and results of a Minerals Management Service (MMS) Fiscal Year (FY) 1990 funded study of major circulation features on the continental shelf between Cape Hatteras, North Carolina, and the mouth of the Chesapeake Bay. The Congress defined the panel membership as one member each to be nominated by the Department and the State of North Carolina. The remaining panel member is to be ". . . chosen jointly by the Secretary and the Governor of North Carolina from nominations submitted by the National Academy of Sciences." (i.e., language in quotes taken directly from the House Report on the FY 1990 Interior Appropriations Bill). We ask that the Academy provide a list of three nominees who are physical oceanographers with research experience in the continental shelf and coastal waters of the U.S. eastern seaboard. Research interest of Gulf Stream frontal events on coastal circulation would be particularly valuable. For your information, the MMS has already nominated Dr. Larry Atkinson, and the State of North Carolina has nominated Dr. John Bane. Since we want to have the panel formed in time to review the draft specifications for our study, we ask that the three nominees be provided within 2 weeks of the date of this letter.

I have enclosed a short description of the study. The design and results of this study will be the object of the panel's review at several times over the next 18-24 months. After evaluation of the results, the panel will deliberate and make recommendations on the adequacy of the existing information in the area to make OCS leasing decisions. The principle concern of the State of North Carolina is that insufficient information exists in the study area on currents and major circulation features. There is also concern that intrusions of colder water along the Virginia and North Carolina coasts may serve to "steer" Gulf Stream eddies into shallow coastal waters. Gulf Stream eddies are perceived as potential pollutant transport mechanisms for oil spills and other operational discharges from OCS development activity in the area.

The proposal by Mobil to conduct exploratory drilling operations approximately 45 miles east-northeast of Cape Hatteras has served to heighten the State of North Carolina's concerns.

If you have any questions, please call Mr. James Lane, Chief, Environmental Studies Unit at (703) 787-1065. We would appreciate your cooperation in assuring additional, timely advice from the Academy on this aspect of our Environmental Studies Program.

Sincerely,

Bruce G. Weetman

Bruce G. Weetman
Regional Director

Enclosure

Regional Studies List Number: 5
Priority Ranking: A2B1
Title: Quasi Steady-State Perturbations and Intrusions of Virginia Coastal Waters Offshore North Carolina
Region: Atlantic
Proposed Period of Performance: 1 year FY 1990
Applicable Planning Area(s): Mid- and South Atlantic
Key Words: Physical oceanography; coastal; Virginia; North Carolina

Description of Proposed Project:

Objectives

A study which will review existing data and satellite imagery to:

1. Characterize the quasi steady-state perturbations south of Cape Hatteras in terms of the circulation field, the frequency and intensity of occurrence, the seasonal variation, the thermal and mass structure, etc.;

2. Describe those factors primarily responsible for these perturbations, if possible, through a review of existing data;

3. Describe those factors that influence the character of these perturbations, including the Gulf Stream, the intrusion of Virginia coastal water into coastal waters south of Cape Hatteras, and meteorological conditions; and

4. Describe the character of the intrusions of Virginia coastal waters south of Cape Hatteras on the continental shelf region in terms of frequency of the occurrence. If possible through review of existing data, characterize the duration of intrusion and seasonal occurrence. If possible, through the review of existing data, characterize the volume of water affected by the phenomena, the current field associated with intrusions, and the thermal and salinity structure of intruding water.

Methods

The study methods will include analysis of existing data and review of satellite images. Existing coastal meteorological data will be necessary to study the impact of meteorological regimes on these perturbations. Mobil Oil Corporation is presently collecting current data off Cape Hatteras from a single current meter mooring in support of the Manteo Project. This small scale, short-duration project is also analyzing satellite imagery. We will coordinate the proposed study closely with this effort.

Area of Study

Mid- and South Atlantic Planning Areas between the Virginia and North Carolina borders and south into Raleigh Bay and Onslow Bay.

Products

Monthly and annual progress reports and a final report by the end of FY 1991.

Justification:

Importance of the study to MMS Decisionmaking

The potential significance of these intrusions as a pollutant transport mechanism was identified during the MMS funded study of Gulf Stream frontal dynamics off North Carolina. This proposed study is a logical continuation of the frontal dynamics study.

Date Information Required and Decision Involved

The results are applicable to pre- and postsale decisions after FY 1991.

Current Status of Information on this Topic

On March 30, 1987, MMS awarded a contract to Evans-Hamilton, Inc., to perform a field study entitled, "Gulf Stream Frontal Dynamics Study Offshore North Carolina." The final report for this study was submitted in March 1989.

Applicability of Information to Issues of Regional or Programmatic Concern

These perturbations can be responsible for Gulf Stream water intrusion onto the Continental Shelf and consequently can be responsible for the transport of any product or by-product of oil and gas operations that occur upstream and have entered into the Gulf Stream, onto the South Atlantic Continental Shelf.

NATIONAL RESEARCH COUNCIL

2101 CONSTITUTION AVENUE WASHINGTON, D.C. 20418

EXECUTIVE OFFICE

RECEIVED BY
ATLANTIC OCS REGION
MAR 0 9 1990.

March 9, 1990

Mr. Bruce G. Weetman, Regional Director
Atlantic OCS Region
Minerals Management Service
381 Elden Street, Suite 1109
Herndon, VA 22070-4817

Dear Mr. Weetman:

Thank you for your letter of January 29, 1990, in which you requested the National Academy of Sciences to provide a list of three physical oceanographers, from which one is to be selected to review the design and results of a study of the physical oceanography of the continental shelf between Cape Hatteras, North Carolina, and the mouth of the Chesapeake Bay.

After consulting with appropriate units of the National Research Council, I am pleased to suggest that you select from the following alphabetical list:

Robert Beardsley, Woods Hole Oceanographic Institution;
William Boicourt, University of Maryland, Horn Point; and
Kenneth Brink, Woods Hole Oceanographic Institution.

Sincerely,

Philip Smith

Philip M. Smith
Executive Officer

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Atlantic OCS Region
381 Elden Street, Suite 1109
Herndon, Virginia 22070-4817

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MAR 12 1990

Ms. Donna D. Moffitt
Outer Continental Shelf Office
19 W. Hargett Street
Raleigh, North Carolina 27601

Dear Ms. Moffitt:

Attached is a letter from the National Research Council nominating three physical oceanographers from which one is to be selected to be the third member of the peer review panel. We will contact you by the end of the week to discuss selection of the third panel member.

Bruce G. Weetman

Bruce G. Weetman
Regional Director

Attachment

NATIONAL RESEARCH COUNCIL

2101 CONSTITUTION AVENUE WASHINGTON, D.C. 20418

EXECUTIVE OFFICE

RECEIVED BY
ATLANTIC OCS REGION

MAR 0 9 1990.

March 9, 1990

Mr. Bruce G. Weetman, Regional Director
Atlantic OCS Region
Minerals Management Service
381 Elden Street, Suite 1109
Herndon, VA 22070-4817

Dear Mr. Weetman:

Thank you for your letter of January 29, 1990, in which you requested the National Academy of Sciences to provide a list of three physical oceanographers, from which one is to be selected to review the design and results of a study of the physical oceanography of the continental shelf between Cape Hatteras, North Carolina, and the mouth of the Chesapeake Bay.

After consulting with appropriate units of the National Research Council, I am pleased to suggest that you select from the following alphabetical list:

Robert Beardsley, Woods Hole Oceanographic Institution;
William Boicourt, University of Maryland, Horn Point; and
Kenneth Brink, Woods Hole Oceanographic Institution.

Sincerely,

Philip Smith

Philip M. Smith
Executive Officer

North Carolina
Department of Administration

James G. Martin, Governor
James S. Lofton, Secretary

Outer Continental Shelf Office
Donna D. Moffitt, Director

March 19, 1990

Mr. Bruce G. Weetman, Regional Director
Atlantic OCS Region
Minerals Management Service
381 Elden Street, Suite 1109
Herndon, VA 22070-4817

Dear Bruce:

Thank you for your letter of March 12 indicating that the National Research Council had nominated three oceanographers for consideration for appointment to the peer review panel. I have discussed the list with several of my advisers and I am told that all three are first class oceanographers. Any of the three would be acceptable to the State. However, since you have asked for a rank order, my first choice is Robert Beardsley of Woods Hole Oceanographic Institute. William Boicourt and Kenneth Brink would make equally acceptable second choices.

I am particularly pleased that your staff has found Mobil's recent document "Characterization of Currents at Manteo Block 467 Off Cape Hatteras, NC" an important work. It synthesizes much of the available current data North of Cape Hatteras and concludes that "the sparseness of physical oceanographic data from the shelf between Cape Hatteras and the [Chesapeake] Bay precludes drawing a conclusion. Since there has never been a comprehensive observational program on this portion of the shelf, a coherent description of the shelf physical oceanography for the area may not be given." pg. 22. To the extent this document can be used to save time and money in the Congressionally-mandated synthesis study, I would support that approach.

If your staff and Mobil would be interested in meeting with the peer review panel to discuss future field measurements on the shelf and in and around Mobil's proposed drill site, please let me know so that I can join you.

Sincerely,

Donna

Donna D. Moffitt

cc: Sec. Jim Lofton

19 W. Hargett St., 9th Floor • Raleigh, North Carolina 27601 • Telephone 919-733-4656

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United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Atlantic OCS Region
381 Elden Street, Suite 1109
Herndon, Virginia 22070-4817

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JUN 21 1990

Dr. Larry Atkinson
Old Dominion University
Department of Oceanography
Norfolk, VA 23529-0276

Dear Dr. Atkinson:

We invite you to attend a 5-day meeting at the Atlantic OCS Region Office in Herndon, Virginia, during the week of July 23-27, 1990.

Enclosed is a contract to cover the cost of your participation in this Congressionally mandated physical oceanography peer review panel. The purpose of the panel meeting will be to:

1. Evaluate the enclosed report entitled: "Characterization of Currents at Manteo Block 467 off Cape Hatteras, North Carolina", and to determine if it is an adequate summary of published and unpublished literature on physical oceanography off North Carolina.
2. Provide recommendations on the need for additional physical oceanographic field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina, in order to make environmental assessments of the potential impacts of OCS development.
3. _If_ additional field measurements are deemed necessary, recommend data collection requirements, sampling criteria, methodology, and station locations necessary to acquire the data.

For your information, Ms. Donna Moffitt, Director of the North Carolina Outer Continental Shelf office has been invited and has indicated she will attend the panel meeting as an interested party.

Please sign and return the contract to the Minerals Management Service/Financial and Administrative Management Division. If you have any questions, please contact Mr. Joseph Mullin at (703)-787-1068. We look forward to your participation in this meeting.

Sincerely,

/s/ Tim Sullivan

Ralph V. Ainger

Enclosures (2)

same ltr sent to:

Dr. Kenneth H. Brink
Woods Hole Oceanographic Institute
Department of Oceanography
Woods Hole, MA 02543

Dr. John M. Bane
Marine Sciences 12-5
Venable Hall C.B. No. 3300
N.C. State University
Chapel Hill, NC 27599

STATEMENT OF WORK

SCIENTIFIC PEER REVIEW PANEL TO REVIEW THE SYNTHESIS OF AVAILABLE PHYSICAL OCEANOGRAPHIC INFORMATION OFFSHORE NORTH CAROLINA

SECTION C

DESCRIPTION/SPECIFICATIONS/STATEMENT OF WORK

C-1 BACKGROUND AND OBJECTIVES

In 1953, the Outer Continental Shelf (OCS) Lands Act (67 Stat. 462) established Federal jurisdiction over the submerged lands of the continental shelf seaward of State boundaries. The Act charged the Secretary of the Department of the Interior with the responsibility for administering mineral exploration and development on the OCS. Subsequent to the passage of the OCS Lands Act of 1953, the Secretary of the Department of the Interior designated the Bureau of Land Management (BLM) as the administrative Agency for leasing submerged Federal lands, and the Geologic Survey for supervising production. In 1982 the Minerals Management Service (MMS) assumed both of these responsibilities.

As part of the mandate under the OCS Lands Act Amendments of 1978 (92 Stat. 629), the Secretary of the Department of the Interior is authorized to conduct studies in areas or regions, of lease sales to ascertain the "environmental impacts on the human, marine, and coastal environments of the OCS and the coastal areas which may be affected by oil and gas development (43 U.S.C. 1346)."

The MMS, and its predecessor agency for the OCS Environmental Studies Program, the BLM, have contracted for a series of biological, chemical, geological, and physical oceanographic studies, designed since 1973 to assess the impacts of offshore petroleum development activity.

Mobil Oil Corporation has submitted a draft Plan of Exploration for an area 44.8 miles northeast of Cape Hatteras, North Carolina. The continental shelf and slope, north of Cape Hatteras, including the area where Mobil Oil is planning exploratory drilling, may be affected by the variability of the coastal circulation, intrusions of Virginia coastal waters, and Gulf Stream meanders.

An improved understanding of the effects which the variability and intrusions of Virginia coastal waters have on circulation patterns offshore North Carolina, can be of importance in determining the fate of an offshore oil spill, as well as operational discharges from drilling operations.

C-2 STATEMENT OF WORK

ITEM 1. Period of Performance

The Period of Performance shall be 3 months.

ITEM 2. Tasks

1. Review the Science Applications International Corporation (SAIC) Report

The panel member shall review and comment on a report entitled: "Characterization of Currents at Manteo Block 467 off Cape Hatteras, North Carolina." The report was submitted by Science Applications International Corporation (SAIC), Raleigh, NC to Mobil Exploration and Producing Services Inc.

The panel members will determine if the report satisfies the requirements of a planned MMS review and synthesis of existing literature, data, and satellite imagery to:

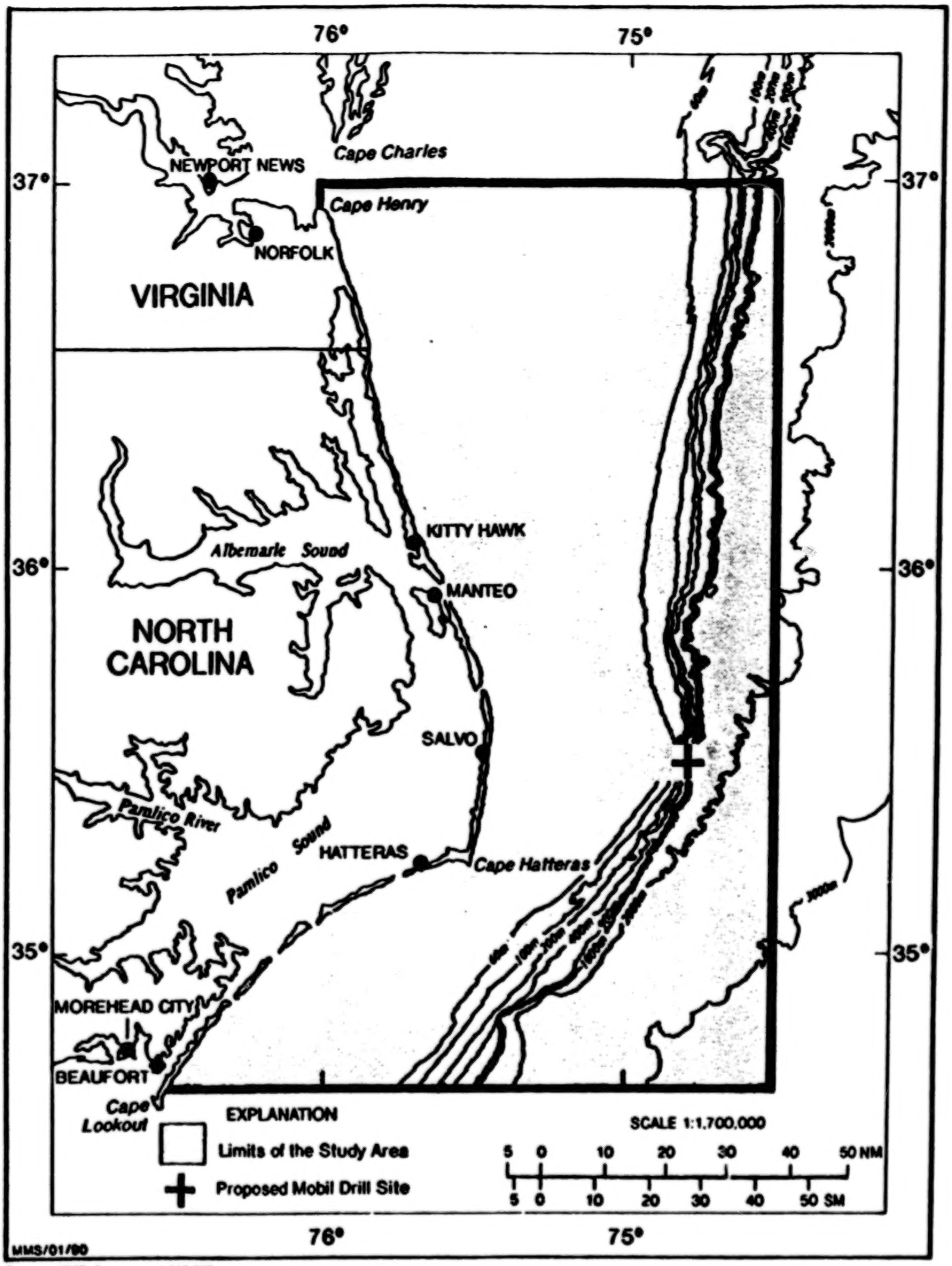
1. Characterize the variability of the circulation of coastal and continental shelf waters offshore North Carolina in terms of the circulation field, duration and frequency of occurrence, seasonal variation, and the thermal and salinity structure.

2. Describe the causative factors responsible for the observed variability; include a thorough review of the hydrography of the study area (Figure 1).

3. Describe factors that influence the character and variability of these perturbations including the Gulf Stream, meteorological conditions, and the intrusions of Virginia coastal waters.

4. Describe the intrusions of Virginia coastal waters onto the continental shelf and slope, offshore North Carolina, in terms of the frequency of occurrence. If possible through a review of existing data, characterize the duration, volume of water involved, seasonal occurrence, thermal and salinity structure of the intruding water, and the current fields associated with the intrusions.

The panel member, having reviewed the SAIC report, shall attend a 5-day Review and Consensus Meeting at the MMS Atlantic OCS Region Office in Herndon, Virginia. The panel member shall meet with the other two members of the peer review panel during the 5-day Review and Consensus Meeting. Upon receiving their charge, the panel will reach a consensus opinion regarding the review of the SAIC report and determine if the report satisfies the requirements (previously listed), of a planned MMS review and synthesis of existing literature, data, and satellite imagery



Source: MMS basemap, 1:750,000

offshore North Carolina.

The panel member shall provide recommendations regarding the need for additional, future field measurements in the area off North Carolina, based upon the review of the available literature and data discussed in the SAIC Report. The panel member, during the 5-day Review and Consensus Meeting, shall meet with the other two members of the peer review panel and reach a consensus opinion on the recommendations regarding the need for additional, future field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina.

If additional field measurements are recommended, the panel member shall meet with the other two members of the peer review panel during the 5-day Review and Consensus Meeting, to develop the data collection requirements, sampling criteria, methodology, and locations necessary to acquire the physical oceanographic data. The peer review panel shall reach a consensus opinion on the requirements of a field measurement program.

At the 5-day Review and Consensus Meeting, the MMS Atlantic OCS Region will supply a rapporteur to take minutes, and a typist to prepare the minutes and the consensus opinions. The consensus opinions will be provided in writing to the Contracting Officers Technical Representative (COTR).

ITEM 2. Deliverables

The panel member shall deliver the following:

1. Typed consensus comments and recommendations based upon the review of a draft report entitled: "Characterization of Currents at Manteo Block 467 off Cape Hatteras, North Carolina." The report was submitted by Science Applications International Corporation (SAIC), Raleigh, NC to Mobil Exploration and Producing Services Inc. The peer review panel will determine if the report satisfies the requirements of a planned MMS review and synthesis of existing literature, data, and satellite imagery, offshore Cape Hatteras, North Carolina.

2. If additional field measurements are recommended, the peer review panel during the 5-day Review and Consensus Meeting will develop and provide typed consensus comments and recommendations on the data collection requirements, sampling criteria, methodology, and locations necessary to acquire the physical oceanographic data.

ITEM 3. Schedule

The MMS will:

1. Send the draft SAIC report to the panel members for review.

2. Conduct a 5-day Review and Consensus Meeting to be held within 21 days after the SAIC report is provided to the panel members.

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Atlantic OCS Region
381 Elden Street, Suite 1109
Herndon, Virginia 22070-4817

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JUL 19 1990

Dr. Larry Atkinson
Old Dominion University
Department of Oceanography
Norfolk, Virginia 23529-0276

Dear Dr. Atkinson:

The physical oceanography peer review panel is scheduled to meet at the Atlantic OCS Region office in Herndon, Virginia, during the week of September 24-28, 1990. We appreciate your cooperation in rescheduling the dates of the meeting.

Please sign and return the contract to cover the cost of your participation in this panel. If you have any questions, please contact Mr. Joseph Mullin at (703) 787-1068.

Sincerely,

Ralph V. Ainger
Regional Supervisor
Leasing and Environment

cc: Donna Moffitt
Dave Szabo

same ltr sent to:

Dr. Kenneth H. Brink
Woods Hole Oceanographic Institute
Department of Oceanography
Woods Hole, Massachusetts 02543

Dr. John M. Bane
Marine Sciences 12-5
Venable Hall C.B. No. 3300
North Carolina State University
Chapel Hill, North Carolina 27599

September 20, 1990

Dear Dr. Atkinson

The proposed agenda and explanation of tasks for the physical oceanography peer review panel is attached for your information. The panel will convene at 9:00 am on September 24, 1990 in the training room 2118 of the Atrium building in Herndon, Virginia.

Entry into office areas of the Atrium building require a security pass. Please contact me at extension 1068 on the telephone, located at each entrance of the building and I will arrange admittance.

In the meanwhile, if you have any questions do not hesitate to contact me at (703)-787-1068. We look forward to your participation.

Sincerely,

Joseph V. Mullin

same letter sent to Drs. Bane and Brink
Donna Moffitt - North Carolina
Mr. Earl Shanks - Mobil Oil Corp.
Dr. Tom Berger - SAIC

Physical Oceanography Peer Review Panel
September 24 - 27, 1990

PROPOSED AGENDA

TIME	ACTIVITY	PARTICIPANT
Monday September 24, 1990		
9:00 am	Welcoming Remarks	MMS
	Introduction of Attendees	MMS
	Charge to the panel including explanation of Tasks 1,2, and 3. (attached)	MMS/PANEL
	Begin evaluation of the "SAIC" prepared report entitled: "Characterization of Currents at Manteo Block 467 off Cape Hatteras, North Carolina". (TASK 1)	PANEL/MMS
	Draft consensus report on the adequacy of the "SAIC" report. (TASK 1)	PANEL
12:00	Lunch	
1:00 pm	Review and edit the draft consensus report on the adequacy of the "SAIC" report. (TASK 1).	PANEL
	Begin discussions on the need, if any, for additional physical oceanographic field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina in order to make environmental assessments of the potential impacts of OCS development. (TASK 2)	PANEL/MMS
4:30 pm	Adjourn	

TIME	ACTIVITY	PARTICIPANT
Tuesday September 25, 1990		
9:00 am	**Review final consensus report on the adequacy of the "SAIC" report. Have panel approve consensus report. (TASK 1 COMPLETE)**	**PANEL/MMS**
	Reach consensus on the need for additional physical oceanographic field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina. (TASK 2)	**PANEL**
	Draft consensus report regarding the need for additional physical oceanographic field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina. (TASK 2)	**PANEL**
12:00	**Lunch**	
1:00 pm	**Review and edit the draft consensus report regarding the need for additional physical oceanographic field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina. (TASK 2)**	**PANEL**
	If additional field measurements are deemed necessary by the panel, begin discussions to recommend data collection requirements, sampling criteria, methodology, and station locations necessary to acquire the data. (TASK 3)	**PANEL**
	Draft consensus report on the data collection requirements. (TASK 3).	**PANEL**
4:30 pm	**Adjourn**	

TIME	ACTIVITY	PARTICIPANT
Wednesday September 26, 1990		
9:00 am	Review final consensus report regarding the need for additional physical oceanographic field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina. Have panel approve consensus report. (TASK 2 COMPLETE)	PANEL/MMS
12:00	Lunch	
1:00 pm	Review and edit draft consensus report on the data collection requirements. (TASK 3	PANEL
	Review final consensus report on data collection requirements. Have panel approve consensus report. (TASK 3 COMPLETE)	PANEL/MMS
4:30 pm	Adjourn	
Thursday September 27, 1990		
9:00 am	Items not accomplished during the previous three days will be completed today.	PANEL
12:00	Lunch	
1:00 pm	Items not accomplished during the previous three days will be completed today.	PANEL
4:30 pm	Closing Remarks/Panel Adjourns	

Explanation of Tasks

TASK 1. Evaluate the Science Applications International Corporation (SAIC) prepared report entitled: "Characterization of Currents at Manteo Block 467 off Cape Hatteras, North Carolina", and determine if it is an adequate summary of published and unpublished literature on physical oceanography off North Carolina.

TASK 2. Evaluate the need for additional physical oceanographic field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina, in order to make environmental assessments of the potential impacts of OCS development.

TASK 3. If additional field measurements are deemed necessary, recommend data collection requirements, sampling criteria, methodology, and station locations necessary to acquire the data.

North Carolina Peer Review Panel Members

Dr. Larry Atkinson
Smith Professor
Old Dominion University
Department of Oceanography
Norfolk, Virginia 23529-0276
(804)-683-4926
(804)-683-5303 fax

Dr. John M. Bane
Marine Sciences Program
12-5 Venable Hall
University of North Carolina
Chapel Hill, North Carolina 27599-3300
(919)-962-1252
(919)-962-5604 fax

Dr. Kenneth H. Brink
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543
(508)-548-1400 ext. 2535
(508)-457-2181 fax

Physical Oceanography Peer Review Panel
September 24 - 26, 1990

Attendees

Peer Review Panel Members

Dr. Larry Atkinson, Old Dominion University
(Minerals Management Selected)

Dr. John Bane, University of North Carolina
(North Carolina Selected)

Dr. Kenneth Brink, Woods Hole Oceanographic Institution
(Joint MMS/NC Selected)

Minerals Management Service

Mr. Joseph Mullin, Atlantic OCS Region

Mr. Jim Lane, Atlantic OCS Region

Mr. David Browne, Atlantic OCS Region

Mr. Barry Clark, Atlantic OCS Region

Mr. Darryl Francois, Atlantic OCS Region

Mr. Keith Good, Atlantic OCS Region

Dr. David Johnson, Branch of Environmental Studies

Dr. Walter Johnson, Branch of Environmental Modeling

North Carolina State Representative

Ms. Donna Moffitt, Director, North Carolina OCS Office

Mobil Oil Corporation

Dr. Earl Shanks

Science Applications International Corporation

Dr. Thomas J. Burger

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Atlantic OCS Region
381 Elden Street, Suite 1109
Herndon, Virginia 22070-4817

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SURNAME
M. Clark 10/26
SURNAME
JPM 10/26
SURNAME
Sullivan 10/29
SURNAME

SURNAME

SURNAME

OCT 29 1990

Dr. Kenneth H. Brink
Woods Hole Oceanographic Institution
Department of Oceanography
Woods Hole, Massachusetts 02543

Dear Dr. Brink:

On behalf of the U.S. Department of the Interior's Minerals Management Service (MMS), I want to thank you for your participation in the North Carolina Physical Oceanography panel meeting. Your valuable contributions have helped us in determining the requirements for a planned MMS synthesis of existing literature, data, and satellite imagery. Your expertise in oceanography has aided the MMS in determining the information needed to adequately understand the physical oceanography of the Cape Hatteras region and the requirements of a field program necessary to acquire the data.

The final draft panel report is attached for your review. Please provide your comments or recommendations by November 9, 1990. If you have any questions or need additional information, please contact me at (703)-787-1068.

Sincerely,

Joseph Mullin

Enclosure

bcc: ES&LS File, ES&LS Chron
LMS:AOCS:JMullin:mc:787-1074:10/26/90
disk:mullinwp51:fname:thanks.mss

Same letter sent to:

Dr. John M. Bane	Dr. Larry Atkinson
Marine Sciences 12-5 Venable Hall	Smith Professor
C.B. No. 3300	Old Dominion University
North Carolina State University	Department of Oceanography
Chapel Hill, North Carolina 27599	Norfolk, Virginia 23529-0276

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Atlantic OCS Region
381 Elden Street, Suite 1109
Herndon, Virginia 22070-4817

Dr. Larry Atkinson
Smith Professor
Old Dominion University
Department of Oceanography
Norfolk, Virginia 23529-0276

JAN 14 1991

Dear Dr. Atkinson:

Enclosed is a final proof copy of the North Carolina Physical Oceanography Panel Report. We would like your review before printing and distribution to ensure that we have accurately incorporated comments on the draft version. If this report accurately reflects the findings and recommendations of the panel, please indicate your approval by signing in the space below and returning this letter in the enclosed envelope.

Please return this letter within two weeks so we can include it in the report appendix. Thanks again for an excellent job. If you have any questions or comments on the report or request, please call me at (703) 787-1063.

Sincerely,

Timothy F. Sullivan
Chief, Environmental Studies
and Leasing Section

Enclosure

Approve:

Dr. Larry Atkinson ____________________ Date ____________________

cc: Dr. John Bane
Dr. Kenneth H. Brink

bcc: ES&LS File, ES&LS Chron
LMS:AOCS:Mullin:mc:787-1074:01/11/91
disk:mullinwp5.1:fname:accltr.mss

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Atlantic OCS Region
381 Elden Street, Suite 1109
Herndon, Virginia 22070-4817

JAN 14 1991

Dr. Larry Atkinson
Smith Professor
Old Dominion University
Department of Oceanography
Norfolk, Virginia 23529-0276

Dear Dr. Atkinson:

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Sincerely,

Timothy F Sullivan

Timothy F. Sullivan
Chief, Environmental Studies
and Leasing Section

Enclosure

Approve:

Larry P. Atkinson
Dr. Larry Atkinson

January 27, 1991
Date

cc: Dr. John Bane
Dr. Kenneth H. Brink

UNIVERSITY
of
NORTH CAROLINA
Marine Sciences Program

January 23, 1991

Mr. Timothy F. Sullivan
Chief, Environmental Studies and Leasing Section
Atlantic OCS Region
381 Elden Street, Suite 1109
Herndon, Virginia 22070-4817

Dear Tim:

Enclosed is your letter requesting approval of the final version of the North Carolina Physical Oceanography Panel Report with my signature. I found only one item in my last reading of the Report that needs attention, and that I had not seen earlier. One of the arrows to the telemery moorings in Figure 1 is placed incorrectly. The upper arrow should point to the current meter mooring on the 60 m isobath on the Duck Line. The text on page 12 which identifies the telemetry moorings is correct.

It has been my pleasure to serve on the Physical Oceanography Panel thus far. I hope we may see some interesting and informative studies result from our deliberations.

Sincerely,

John Bane

John M. Bane, Jr.
Professor

encl.
JMB/mac

Marine Sciences Program
CB #3300 Venable Hall
University of North Carolina
Chapel Hill, North Carolina 27599-3300
(919) 962-1252

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Atlantic OCS Region
381 Elden Street, Suite 1109
Herndon, Virginia 22070-4817

Dr. John M. Bane
Marine Sciences Program
12-5 Venable Hall
University of North Carolina
Chapel Hill, North Carolina 27599

JAN 14 1991

Dear Dr. Bane:

Enclosed is a final proof copy of the North Carolina Physical Oceanography Panel Report. We would like your review before printing and distribution to ensure that we have accurately incorporated comments on the draft version. If this report accurately reflects the findings and recommendations of the panel, please indicate your approval by signing in the space below and returning this letter in the enclosed envelope.

Please return this letter within two weeks so we can include it in the report appendix. Thanks again for an excellent job. If you have any questions or comments on the report or request, please call me at (703) 787-1063.

Sincerely,

Timothy F Sullivan

Timothy F. Sullivan
Chief, Environmental Studies
and Leasing Section

Enclosure

Approve:

John M. Bane

Dr. John M. Bane

23 Jan 1991

Date

cc: Dr. Larry Atkinson
Dr. Kenneth H. Brink

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Atlantic OCS Region
381 Elden Street, Suite 1109
Herndon, Virginia 22070-4817

JAN 14 1991

Dr. Kenneth H. Brink
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

Dear Dr. Brink:

Enclosed is a final proof copy of the North Carolina Physical Oceanography Panel Report. We would like your review before printing and distribution to ensure that we have accurately incorporated comments on the draft version. If this report accurately reflects the findings and recommendations of the panel, please indicate your approval by signing in the space below and returning this letter in the enclosed envelope.

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Sincerely,

Timothy F Sullivan

Timothy F. Sullivan
Chief, Environmental Studies
and Leasing Section

Enclosure

Approve:

Kenneth H. Brink
Dr. Kenneth H. Brink

11-7/91
Date

cc: Dr. Larry Atkinson
Dr. John M. Bane

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.

March 3, 1849

U.S. DEPARTMENT OF THE INTERIOR MINERALS MANAGEMENT SERVICE

116

END

DATE FILMED

10 / 21 / 91